## FUSED FILAMENT TUFT AND FUSED BRUSH STRIP

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates generally to brush clusters and more specifically to a fused filament tuft which retains a plurality of filaments in a cluster that allows for greater fill density than other prior art manufacturing processes. The present invention also relates general to brushes and more specifically to a fused brush strip with greater flexibility than that of the prior art.

### 2. Discussion of the Prior Art

There are numerous ways of retaining a plurality of filaments to form a brush element. With a knot type brush, wires are twisted into a knot shape. Knotted wires have to be trimmed to yield consistent wire ends. With pencil type brushes, wires are either clamped, swaged, or glued and retained in a wire holder. Combinations of the above may also be inserted into the wire holder. Wires are usually retained in the wire holder by friction. Using friction alone cannot guarantee the wires from coming out of the wire holder. Swaging tends to distort the wire holder whose dimension is crucial for fitting into a tool.

With a staple set, a bundle of wires are bent into an U-shaped tuft and then stapled onto the brush assembly. Wires are held inside the brush assembly by the friction of stapling wire relative to the brush assembly. Using friction alone cannot prevent the wires from pulling out of the brush assembly. The staple set

technique is impractical for retaining a large quantity of filaments.

Laced tuft is similar to the staple set technique. A bundle of wires are bent into a U-shaped tuft and then tied by a lacing wire at the bottom of the U-bend. The laced tuft technique cannot be used in high-speed power brush applications. The laced tuft technique is impractical for retaining a large quantity of filaments. The U-shaped wire tuft has to be trimmed if a consistent filament is required. Crimped wire brushes are manufactured by passing wires through crimping devices to impose a sinusoidal waveform on the straight wires. Then a bundle of crimped wire is bent around a securing device such as a pin, wire or ring. The wire ends have to be trimmed to yield a consistent brush face.

Traditional strip brush manufacturing typically bends filaments about a retaining wire to form a U-shape which is retained in a channel formed in a base. The filament density is largely limited by the retaining components. The flexibility of a strip brush is also determined by the channel. Precision brush strips have been recently utilized in the sealing of turbine shafts and the shrouding of turbine blade housings.

It is well known in the art to weld a retaining rail to at least one side of a plurality of filaments to form a strip brush. The retaining rails add an extra thickness to the strip brush which reduces its effectiveness. The flexibility of the brush strip is limited by the retaining rails.

Accordingly, there is a clearly felt need in the art for a fused filament tuft which has a greater fill density than prior art manufacturing processes, allows the combining of greater numbers of filaments than prior art manufacturing processes, and does not require secondary trimming of the filaments. There is also a clearly felt need in the art for a fused brush strip with no retaining rails which allows thereof to have less width and greater flexibility than that of the prior art.

## SUMMARY OF THE INVENTION

The present invention provides a fused filament tuft which is superior to other prior art manufacturing processes in several ways. A fused filament tuft includes a plurality of filaments which are fused on at least one end to form a cluster or tuft. A cross section of the tuft of filaments may assume any shape, such as round, rectangular, or oval. When using metallic filaments, the tufts may be formed by positioning a bundle of metallic filaments in a vertical orientation and preferably fusing one end thereof with TIG welding. Other fusing processes besides TIG welding may also be used. The bundle of metallic filaments is preferably retained in a collet, guide tube, or the like and advanced to provide the proper length for cutoff. Cutting an end off the bundle provides a tuft. Cutting is executed with any suitable process. The other end of a fused filament tuft may also be welded to produce a double fused filament tuft. Filaments fabricated from synthetic materials may be fused into tufts with sonic welding, but other fusing processes may also be used.

A nonfused end of each tuft may be flared by squeezing the perimeter of the tuft at substantially the fused end thereof. It is preferably to have two sets of squeezing dies which open perpendicular to each other. A plurality of tufts may be captured to form a brush. The fused ends of each tuft may be captured by various mechanical means such as molding, swaging, interference fit, or brazing to form a brush with a base structure.

The present invention also provides a fused brush strip which is more flexible than that of the prior art. The fused brush strip is an unified lengthwise progression of metallic filaments which can exceed twenty inches. The fused brush strip does not require a base structure to retain a plurality of filaments. The filaments are joined on one end thereof. The fused brush strip is created by first retaining the filaments in a holding fixture. The holding fixture is traversed lengthwise with a constant speed relative to an electron beam of an electron beam welding machine or an electrode of a TIG welding machine. One end of each of the filaments are welded such that they form a single lengthwise assembly.

Accordingly, it is an object of the present invention to provide a fused filament tuft which requires no secondary trimming.

It is a further object of the present invention to provide a fused filament tuft which may be easily retained in a base structure to form a brush.

It is yet a further object of the present invention to provide a fused filament tuft which has a large area of filament

distribution at a nonfused end.

It is yet a further object of the present invention to provide a fused filament tuft which allows all filaments to be maintained in precise parallelism to each other.

It is yet a further object of the present invention to provide a double fused filament tuft which may be easily handled and trimmed at a later time.

It is yet a further object of the present invention to provide a fused brush strip which does not require a base structure to retain a plurality of filaments.

Finally, it is another object of the present invention to provide a fused brush strip with flared filaments which has a wider distribution of filaments at a nonfused end.

These and additional objects, advantages, features and benefits of the present invention will become apparent from the following specification.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a fused filament tuft with a round cross section in accordance with the present invention.

Figure 1a is a perspective view of a fused filament tuft with a rectangular cross section in accordance with the present invention.

Figure 1b is a perspective view of a double fused filament tuft with a round cross section in accordance with the present invention.

Figure 2 is a perspective view of a plurality of filaments retained in a collet before fusion in accordance with the present invention.

Figure 3 is a perspective view of two sets of squeezing dies which are used to indent the filaments in a fused tuft to cause a nonfused end to be flared in accordance with the present invention.

Figure 4 is an enlarged perspective view of a squeezing die in accordance with the present invention.

Figure 4a is an enlarged cross sectional view of a single squeeze die in accordance with the present invention.

Figure 5 is a side view of a fused filament tuft after thereof has been squeezed in accordance with the present invention.

Figure 6 is a perspective view of a base structure which has been swaged to retain a plurality of fused filament tufts to form a brush in accordance with the present invention.

Figure 7 is a perspective view of a base structure which has been molded or sintered around a plurality of fused filament tufts to form a brush in accordance with the present invention.

Figure 8 is a partially exploded perspective view of a base structure which has interference fit holes for receiving a plurality of fused filament tufts to form a brush in accordance with the present invention.

Figure 9 is a perspective view of a fused brush strip with filaments oriented perpendicular with respect to the length thereof in accordance with the present invention.

Figure 10 is a perspective view of a plurality of filaments being retained in a fixture before fusion of one end thereof to form a brush strip in accordance with the present invention.

Figure 11 is a perspective view of a fused brush strip with filaments oriented at a prescribed angle with respect to the length thereof in accordance with the present invention.

Figure 12 is a perspective view of a set of squeezing dies which are used to indent filaments in a fused brush strip to cause a nonfused end to be flared in accordance with the present invention.

Figure 13 is a perspective view of a fused brush strip after thereof has been squeezed in accordance with the present invention.

Figure 14 is a perspective view of a fused brush strip formed in a curved shape to be received by a brush seal assembly in accordance with the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference now to the drawings, and particularly to figure 1, there is shown a perspective view of a fused filament tuft 1. The fused filament tuft 1 includes a plurality of filaments 10 which are fused on at least one end to form a cluster or tuft. With reference to figure 1a, a cross section of the fused filament tuft may have any shape, such as round, rectangular, or oval. A rectangular shape is shown in figure 1a. With reference to figure 1b, a double fused filament tuft 2 includes the plurality of filaments 10 which are fused on both ends. One of the fused ends 14 may be cut off to provide an open end.

Figure 2 shows a bundle of metallic filaments 12 retained by a collet 100 in a vertical orientation. The metallic filaments 12 are preferably fused on one end to form a tuft using an electrode 102 of a TIG welding operation, but other methods of fusing the metallic filaments may also be used. After the bundle of metallic filaments 12 are fused on one end, the bundle of metallic filaments 12 are cut to length to form the fused filament tuft 1. The cutting operation may be implemented with a shear cutter, water jet, or any other suitable process. Filaments fabricated from synthetic materials may be fused into tufts with sonic welding, or any other suitable fusing process.

With reference to figures 3 - 5, a nonfused end of each fused filament tuft 1, may be flared by squeezing the perimeter of the filaments 10 at substantially a fused end 14 thereof. It is preferably to have a first set of squeezing dies 106 and 107 which open perpendicular to a second set of squeezing dies 108 and 109. Each squeezing die has a contoured cavity 110 to receive the cross section of the fused filament tuft 1. The contoured cavity 110 preferably has a pointed edge 112 cross section to form an indentation 16 in the perimeter of the fused filament tuft 1.

A plurality of fused filament tufts 1 may be captured in a base structure to form a brush. With reference to figure 6, a plurality of fused filament tufts 1 are retained in a base structure 18. A lengthwise retention cavity 20 with two walls is formed in an end of the base structure 18. The lengthwise retention cavity 20 is sized to receive the fused end 14 of each fused filament tuft 1.

After the plurality of fused filaments tufts 1 are inserted into the lengthwise retention cavity 20, the side walls 22 of the lengthwise retention cavity 20 are swaged over the plurality of fused ends 14.

With reference to figure 7, a plurality of fused ends 14 are captured in a base structure 24 which is plastic molded around the fused ends 14. The base structure 24 could also be formed by sintering. With reference to figure 8, a plurality of tuft holes 28 are formed in a base structure 26. Each tuft hole 28 may be sized to have an interference fit with the fused end 14 of each fused filament tuft 1. Each tuft hole 28 may also be sized to slidably receive the fused end 14 of each fused filament tuft 1. The fused ends 14 would also be brazed to the base structure 26.

With reference to figures 9 and 10, a brush strip 30 is an unified lengthwise progression of metallic filaments 10 which may exceed twenty inches. The fused brush strip 30 does not require a base structure to retain the plurality of filaments 10. The filaments 10 are joined together on a fused end 32. Preferably, the brush strip 30 is created by first retaining a bundle of metallic filaments 13 in a holding fixture 34. The holding fixture 34 is traversed lengthwise with a constant speed relative to an electron beam of an electron beam welding machine or an electrode 104 of a TIG welding system. One end of each of the metallic filaments 13 are fused such that they form a single lengthwise assembly.

With reference to figure 11, an angled fused brush strip 36 includes a plurality of filaments 10 which are oriented at a prescribed angle with respect to the length thereof and are joined together on a fused end 38.

With reference to figures 12, a pair of squeezing dies 112 are positioned on both sides of the fused brush strip 30 at substantially the fused end 32. The pair of squeezing dies 112 are brought together to form a flared nonfused end as shown in figure 13. The squeezing dies 112 form an indentation 40 in both sides of the fused brush strip 30.

With reference to figure 14, the fused brush strip 30 is flexed to form a curved portion of a turbine seal. The fused brush strip 30 is captured between a first retainer 114 and a second retainer 116. The first and second retainers are secured with a plurality of fasteners 118. The fused brush strip 30 may be flexed into other nonlinear shapes.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.